

CLAIMS

What we claim is:

5 1. A method of controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:
 controlling the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan;
 detecting, from above-ground, cutting tool movement;
10 accessing, during HDD machine operation, one or more control programs, each of the control programs causing the HDD machine to execute a sequence of pre-defined HDD machine actions; and
 executing a particular control program of the one or more control programs to augment movement of the drill pipe or cutting tool.

15 2. The method of claim 1, wherein detecting cutting tool movement comprises confirming that the cutting tool is progressing along the underground path.

20 3. The method of claim 1, wherein the particular control program defines a sequence of cutting tool location detection actions, and detecting cutting tool movement comprises detecting cutting tool orientation during execution of the sequence of cutting tool location detection actions.

25 4. The method of claim 1, wherein the particular control program defines a sequence of cutting tool location detection actions, and detecting cutting tool movement comprises detecting cutting tool depth during execution of the sequence of cutting tool location detection actions.

30 5. The method of claim 1, wherein the particular control program defines a sequence of cutting tool location detection actions, and detecting cutting tool movement

comprises detecting cutting tool location during execution of the sequence of cutting tool location detection actions.

6. The method of claim 1, wherein detecting cutting tool movement
5 comprises detecting a deviation of the cutting tool from the underground path, and execution of the particular control program augments movement of the cutting tool to change a heading of the cutting tool.

7. The method of claim 6, wherein the heading of the cutting tool is changed
10 to direct the cutting back to the underground path.

8. The method of claim 6, wherein the heading of the cutting tool is purposefully changed to direct the cutting tool away from the underground path.

9. The method of claim 1, wherein detecting cutting tool movement
15 comprises detecting an underground obstruction, and execution of the particular control program augments movement of the cutting tool to avoid the detected underground obstruction.

10. The method of claim 1, wherein accessing the one or more control
20 programs further comprises manually selecting the particular control program for execution.

11. The method of claim 1, wherein accessing the one or more control
25 programs further comprises automatically selecting the particular control program for execution.

12. The method of claim 1, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or
30 reamer actions to enhance progression of the boring tool or reamer through earth.

13. The method of claim 1, wherein the one or more control programs define a sequence of rod loading or unloading actions.

5 14. The method of claim 1, wherein the HDD machine comprises a mud system, further wherein the one or more control programs define a sequence of mud system actions.

10 15. The method of claim 1, wherein the one or more control programs comprise instructions that replicate an operator defined sequence of HDD machine actions.

16. The method of claim 1, further comprising:
manually performing the sequence of pre-defined HDD machine actions;
and

15 storing program instructions during manual performance of the sequence of pre-defined HDD machine actions, the one or more control programs comprising the stored program instructions.

20 17. The method of claim 1, further comprising detecting a change in an HDD machine performance characteristic, wherein executing the particular control program modifies movement of the drill pipe or cutting tool in response to the detected change in the HDD machine performance characteristic.

25 18. The method of claim 1, further comprising inputting a set of initial HDD machine operating parameters for controlling drill pipe or cutting tool movement, wherein executing the particular control program modifies execution of the set of initial HDD machine operating parameters.

19. The method of claim 1, wherein controlling the HDD machine comprises autonomously controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan.

5 20. The method of claim 1, wherein controlling the HDD machine comprises manually controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan, further wherein executing the particular control program augments or takes over manual control of the HDD machine.

10 21. A system for controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:
an above-ground locator;
a user interface comprising a user input device; and
a controller, communicatively coupled to the user interface, configured to
15 control the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan, the controller, during HDD machine operation, accessing one or more control programs each causing the HDD machine to execute a sequence of pre-defined HDD machine actions, the controller executing a particular control program of the one or more control programs to augment movement
20 of the drill pipe or cutting tool.

22. The system of claim 21, wherein the cutting tool comprises a boring tool.

23. The system of claim 21, wherein the cutting tool comprises a reamer.

25 24. The system of claim 21, wherein the user interface comprises a display.

25. The system of claim 21, wherein the user interface is situated at or on the HDD machine.

26. The system of claim 21, wherein the user interface is situated at or on the above-ground locator.

27. The system of claim 21, wherein a first user interface is situated at or on the above-ground locator, and a second user interface is situated at or on the HDD machine.

28. The system of claim 21, wherein the controller is situated at or on the HDD machine.

29. The system of claim 21, wherein the controller is situated at or on the above-ground locator.

30. The system of claim 21, wherein the controller accesses the one or more control programs in response to a manual instruction received by the user input device.

31. The system of claim 21, wherein the controller accesses the one or more control programs in response to a control signal generated by the controller.

32. The system of claim 21, wherein the controller accesses the one or more control programs in response to information received from the locator.

33. The system of claim 21, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or reamer actions to enhance progression of the boring tool or reamer through earth.

34. The system of claim 21, wherein the one or more control programs define a sequence of rod loading or unloading actions.

35. The system of claim 21, further comprising a mud system, wherein the one or more control programs define a sequence of mud system actions.

36. The system of claim 21, wherein the one or more control programs
5 comprise instructions that replicate an operator defined sequence of HDD machine actions.

37. The system of claim 21, wherein the user input device comprises a start
recording control and a stop recording control, the start recording control actuatable to
10 initiate recording of program instructions during operator performance of the sequence
of pre-defined HDD machine actions, and the stop recording control actuatable to
terminate the recording of program instructions upon terminating the operator
performance of the sequence of pre-defined HDD machine actions, the one or more
control programs comprising the recorded program instructions.

15 38. The system of claim 21, wherein the controller autonomously controls the
HDD machine to move the cutting tool along the underground path in accordance with
the pre-established bore plan.

20 39. The system of claim 21, wherein the controller, in response to operator
inputs received by the user input device, controls the HDD machine to move the cutting
tool along the underground path in accordance with the pre-established bore plan,
further wherein execution of the particular control program by the controller augments
the operator inputs to operate the HDD machine in a semi-automatic or automatic
25 mode.

40. A system for controlling a horizontal directional drilling (HDD) machine having a cutting tool coupled to a drill pipe, comprising:

means for controlling the HDD machine to move the cutting tool along an underground path in accordance with a pre-established bore plan;

5 means for detecting cutting tool movement from above-ground;

means for accessing, during HDD machine operation, one or more control programs, each of the control programs causing the HDD machine to execute a sequence of pre-defined HDD machine actions; and

10 means for executing a particular control program of the one or more control programs to augment movement of the drill pipe or cutting tool.

41. The system of claim 40, further comprising means for confirming that the cutting tool is progressing along the underground path.

15 42. The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool orientation during execution of the sequence of cutting tool location detection actions.

20 43. The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool depth during execution of the sequence of cutting tool location detection actions.

25 44. The system of claim 40, wherein the particular control program defines a sequence of cutting tool location detection actions, and the means for detecting cutting tool movement comprises means for detecting cutting tool location during execution of the sequence of cutting tool location detection actions.

45. The system of claim 40, wherein the means for detecting cutting tool movement comprises means for detecting a deviation of the cutting tool from the underground path, and execution of the particular control program by the execution means augments movement of the cutting tool to change a heading of the cutting tool.

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46. The system of claim 40, wherein the means for detecting cutting tool movement comprises means for detecting an underground obstruction, and execution of the particular control program by the execution means augments movement of the cutting tool to avoid the detected underground obstruction.

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47. The system of claim 40, wherein the means for accessing the one or more control programs further comprises means for manually selecting the particular control program for execution.

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48. The system of claim 40, wherein the means for accessing the one or more control programs further comprises means for automatically selecting the particular control program for execution.

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49. The system of claim 40, wherein the cutting tool comprises a boring tool or a reamer, and the one or more control programs define a sequence of boring tool or reamer actions to enhance progression of the boring tool or reamer through earth.

50. The system of claim 40, wherein the one or more control programs define a sequence of rod loading or unloading actions.

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51. The system of claim 40, further comprising a mud system, wherein the one or more control programs define a sequence of mud system actions.

52. The system of claim 40, wherein the one or more control programs comprise instructions that replicate an operator defined sequence of HDD machine actions.

5 53. The system of claim 40, further comprising:
means for manually performing the sequence of pre-defined HDD machine actions; and
means for storing program instructions during manual performance of the sequence of pre-defined HDD machine actions, the one or more control programs
10 comprising the stored program instructions.

54. The system of claim 40, further comprising means for detecting a change in an HDD machine performance characteristic, wherein executing the particular control program by the execution means modifies movement of the drill pipe or cutting tool in
15 response to the detected change in the HDD machine performance characteristic.

55. The system of claim 40, further comprising means for inputting a set of initial HDD machine operating parameters for controlling drill pipe or cutting tool movement, wherein executing the particular control program by the execution means
20 modifies execution of the set of initial HDD machine operating parameters.

56. The system of claim 40, wherein the means for controlling the HDD machine comprises means for autonomously controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore
25 plan.

57. The system of claim 40, wherein the means for controlling the HDD machine comprises means for manually controlling the HDD machine to move the cutting tool along the underground path in accordance with the pre-established bore plan, further wherein executing the particular control program by the executing means
5 augments or takes over manual control of the HDD machine.